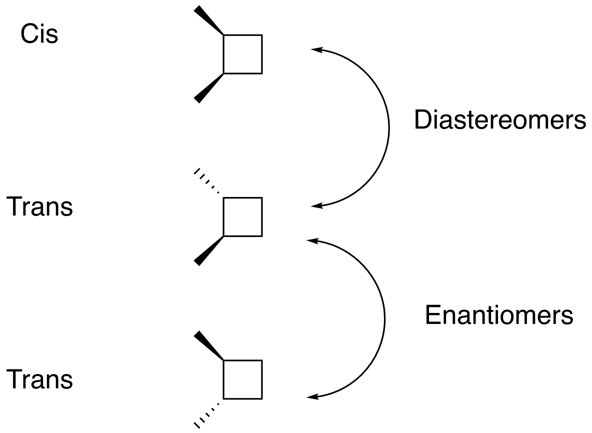
RECALL:

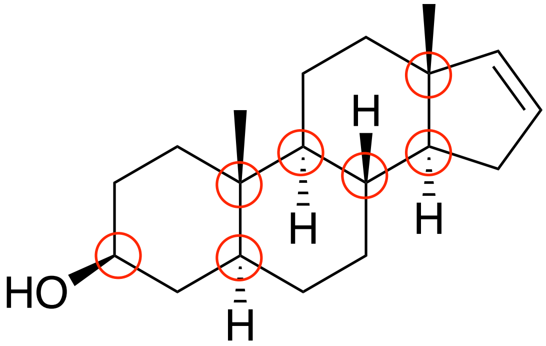


Enantiomers have opposite stereochemistry at **every** stereocenter (chiral center)

Diastereomers are all stereoisomers that are not enantiomers

Pheromones: from Greek "pherein horman" meaning to carry excitement. Discovered by Adolf Butenanot.

Male Pheromone:

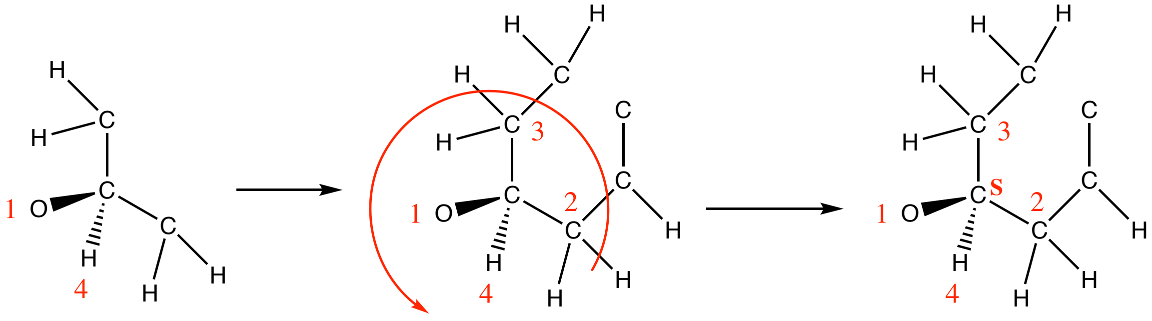


Only about 50 % of the population can smell this compound, which is genetically determined. About half find the smell disgusting while the other half find it tolerable or pleasant.

Can be detected by insects at concentrations of 10^{-17} molar.

Contain 7 stereogenic centers, circled in red above.

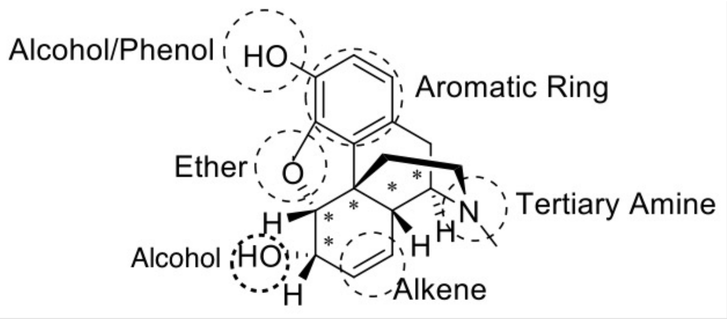
What is the R/S configuration of the carbon attached to OH?



S configuration of stereogenic center

Morphine:

- Is an alkaloid, meaning it contains nitrogen, can be isolated from a plant (or bacteria) and is considered a natural product.
- From Morpheus, Greek god of sleep
- Opium: Sap from the seed pod of opium poppy (*Papaver somniferum*)
    - (poppy sleep-carrying)
- ~10% of opium is morphine
- Morphine is used as an analgesic
- Heroin (diacetylmorphine) is even more potent (and more addictive)



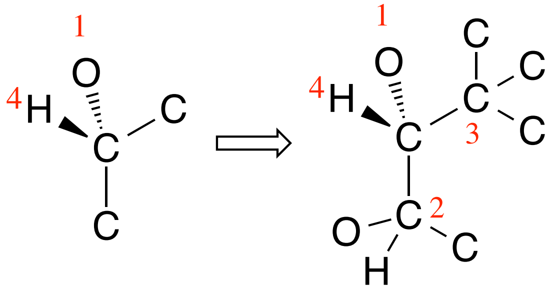
- 5 stereogenic centers in morphine (represented by *) – Nitrogen NOT a stereogenic centre because the methyl group can move up or down
    - 2^5 = 32 stereoisomers possible, where:
    - 1 morphine (itself)
    - 1 enantiomer
    - 30 diastereoisomers

Mithridates VI (135-63 BC)

- Poisoned slaved and attempted to cure them using mixtures of different plants
- Favorite mixture was Theriac, which contained morphine

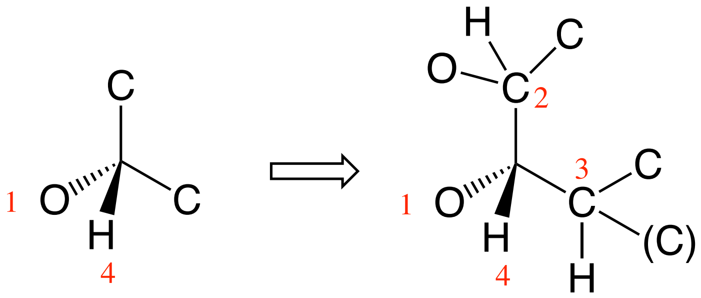
Examples of Configuration in Stereocenters of Morphine

Configuration at the **ether** stereocenter:



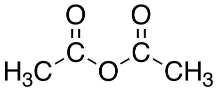
- Cannot assign 2, 3 at first try
- At the second atoms in the chain, there is a difference. The alcohol carbon is attached to one oxygen, one carbon, and one hydrogen. It has a higher priority than the other carbon which is attached to three carbons.
- Count 1, 2, 3: Counterclockwise
- This center is *R* and not *S* because the lowest priority group (the hydrogen) is pointing toward the front, not to the back.

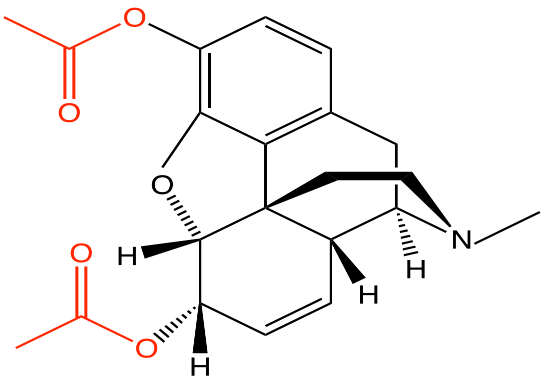
Configuration at the **alcohol** stereocenter:



- Cannot assign 2, 3 at first try
- At the second atoms in the chain, the eth carbon is attached to one oxygen, one carl and one hydrogen. It has a higher priority the alkene carbon which is attached to tw carbons and one hydrogen
- Count 1, 2, 3: Clockwise
- This center is *S* and not *R* because the lo priority group (the hydrogen) is pointing toward the front, not the back

If you substitute CH_3COO for the two alcohol residues in morphine by reacting with

acetic anhydride ( $H_3C{-}C({=}O){-}O{-}C({=}O){-}CH_3$), you then create **HEROIN.**

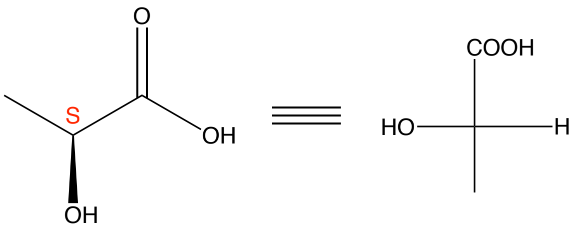


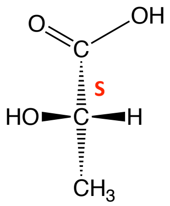
1000 times stronger
and more addictive
than morphine

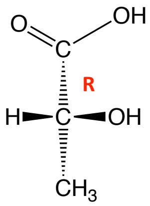
Fischer Projections

A method of drawing chemical structures, where the horizontal components are coming towards you and the vertical ones are going back.

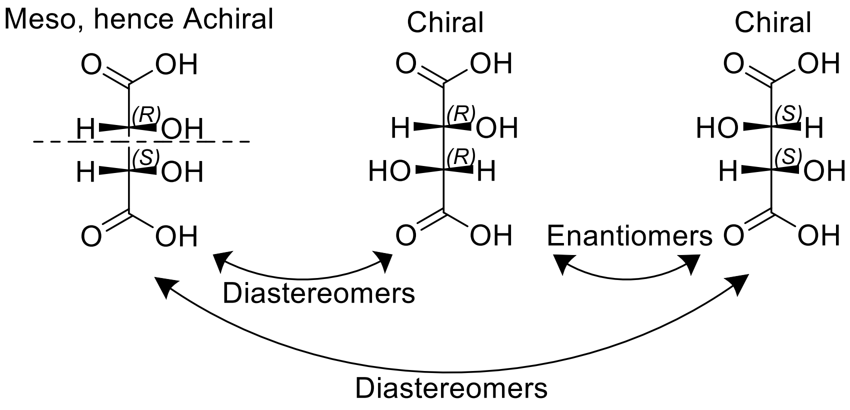
Example #1: Lactic Acid







Example #2: Tartaric acid



Meso compounds have stereogenic centers but contain a plane of symmetry and are achiral

Racemic mixtures (or racemate) contain a 1:1 ratio of each enantiomer

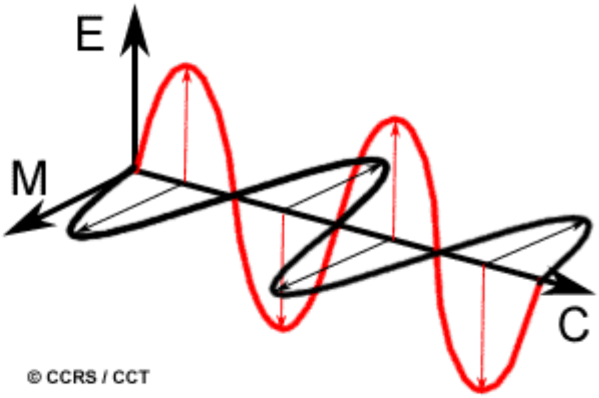
Physical Properties of Enantiomers

- Same physical properties with achiral agents or procedures
  - Melting point, boiling point, solubility in achiral solvents
- Separation of enantiomers (resolution) require a chiral agent
- Diastereomers have different physical properties (m.p, b.p, density, solubility)

Optical Activity

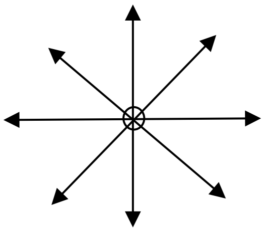
- Rotation of plane of polarized light
- α = measured rotation (°)
- $[\alpha]_D$ = Absolute rotation
  - (+) (clockwise)
  - (-) (counter-clockwise)
- Absolute rotation is 0 ° for achiral molecules

Pure enantiomers show equal but opposite rotation

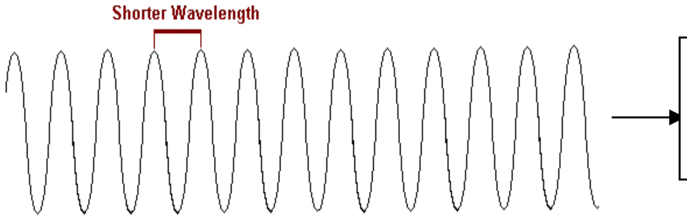


© CCRS / CCT

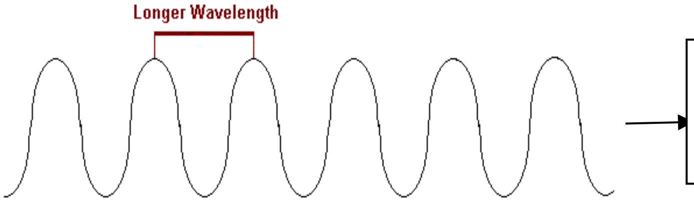
Light has an oscillating electric field (red) combined with a magnetic field (black)



End on view of vector components of normal light. It is possible to polarize light and remove some of those vectors.



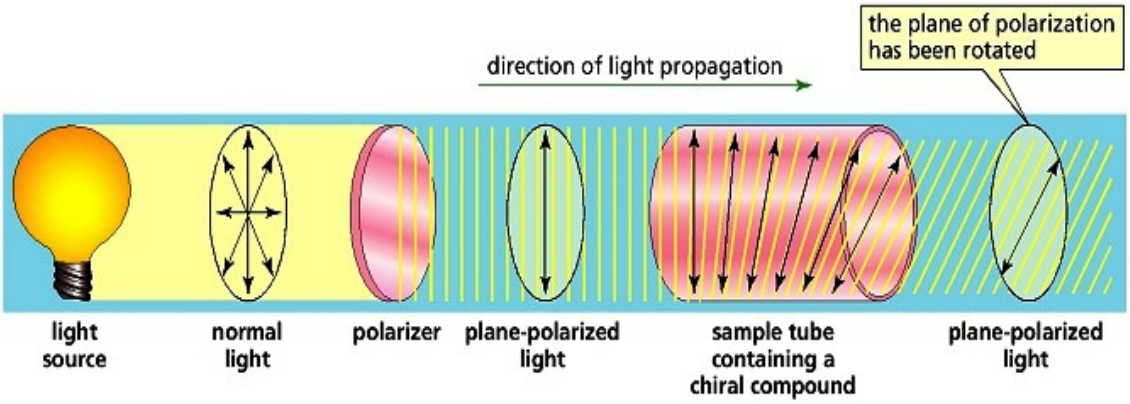
- ➢ Shorter Wavelength
- ➢ Higher Energy
- ➢ Higher Frequency



- ➢ Longer Wavelength
- ➢ Low Energy
- ➢ Low Frequency

$$E = h\nu = \frac{hc}{\lambda}$$

E = energy
H = Planck’s Constant (6.6 x 10^{-34} Joules•sec
ν = frequency
λ = wavelength



Optical Rotation

Factors affecting optical rotation:

- Concentration of compound (c)
- Path length that light travels through the solution (l)

$[\alpha]_D$ = Absolute rotation at the D line of sodium (589 nm or 5890 Å)

$$[\alpha]_D = \frac{\alpha}{c \bullet l}$$

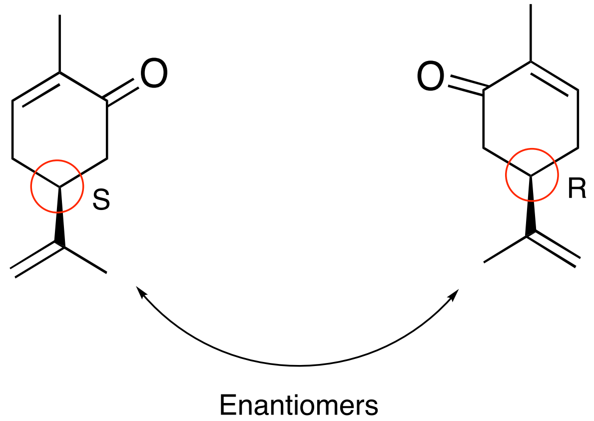
α = measured rotation (°) c = concentration (g/cm^3) l = path length (cm)

D = D-line of sodium light [α] = absolute rotation

Degrees (°) = + : Clockwise (dextrorotatory/D)
- : Anticlockwise (levorotatory/L)

Example: Carvone

$[\alpha]_D = +100^{\circ}$ $[\alpha]_D = -100^{\circ}$ (made up values, not real rotation)



S-carvone (caraway)   R-carvone (spearmint)

Calculating Optical Purity

For this example for S-carvone, assume the pure S enantiomer has +100° rotation

R	**S**	**Rotation (°)**	**Optical Purity (%)**
100 %	0 %	-100 °	100 %
75 %	25 %	-50 °	50 %
50 %	50 %	0 °	0 %
25 %	75 %	+50 °	50 %
0 %	100 %	+ 100 °	100 %

If a solution is an equivalent mix of 1:1 R + S enantiomers, α measured = 0 °

A 50:50 mixture of enantiomers is called a *racemic mixture* (or racemate)

Optical Purity (measured experimentally) = Enantiomeric Excess (ee) (Theoretical value)